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(54) STACKED PIEZOELECTRIC TRANSFORMER

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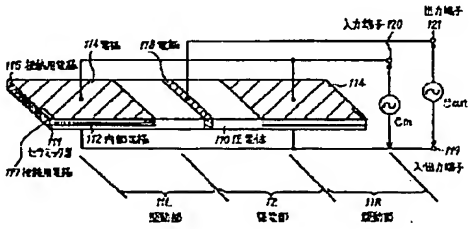

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CLAIMS

[Claim(s)]
[Claim 1] It is classified into three fields of an actuator characterized by providing the following. The band-like electrode prolonged crosswise [of a piezo electric crystal] into a part including the center of the die-length direction of the front face is prepared in said generation-of-electrical-energy section. The laminating of the wrap electrode layer is mostly carried out by turns in the whole region, and the electrode layer of the outermost layer of drum of a laminating is the laminated structure of a wrap gestalt. said two actuators -- respectively -- a piezoelectric-ceramics layer and its piezoelectric-ceramics layer -- In a different field from the principal plane of said piezo electric crystal, the electrode for connection of an electric insulation-lot prepares said electrode layer for each who connects by turns for placing further, and it is set to the laminating mold piezoelectric transformer of ******** structure. The laminating mold piezoelectric transformer characterized by preparing four electrodes for connection of said two actuators in four corners of the piezo electric crystal when seeing a piezo electric crystal from a direction vertical to the principal plane The actuator where a long tabular piezo electric crystal includes one edge in order covering the die-length direction The generation-of-electrical-energy section including the center section of the die-length direction Other-end section
[Claim 2] the laminating mold piezoelectric transformer characterized by the band electrode of four electrode layers of the outermost layer of drum of two actuators established in the principal plane of said piezo electric crystal and the generation-of-electrical-energy section having been alike , respectively , having received in the laminating mold piezoelectric transformer according to claim 1 , and prepare a node with an external circuit in the location equivalent to the knot of machine resonance in the 3rd die-length direction mode of said piezo electric crystal .

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]Especially this invention relates to the laminating mold piezoelectric transformer which an actuator drives by machine resonance in the 3rd die-length direction mode about the laminating mold piezoelectric transformer of a laminated structure.
[0002]
[Description of the Prior Art]for example, -- as the transformation component for high-tension generating in the power circuit in the equipment which needs the high tension of the deflection equipment of television, the electrification equipment of a copying machine, etc. -- the electromagnetism of a former and coil mold -- the transformer has been used. this electromagnetism -- a transformer needs to make [many] the number of the lead wire twisted for obtaining a high transformation ratio with the structure which twisted lead wire around the core of the magnetic substance. therefore, small electromagnetism -- it was dramatically difficult to realize a transformer.
[0003]On the other hand, the piezoelectric transformer using the piezo-electric effect is proposed (for example, C . A . Rosen (C. A.Rosen) and "ceramic transformer" (Ceramic Transformer) proceeding OBU electro nick component symposium [1957 (Proc.of Electronic Component Symposium (1957), the 256-211st page)]). The perspective view of an example of the typical Rosen mold piezoelectric transformer which is a piezoelectric transformer is shown in

drawing 3. With reference to drawing 3, the long tabular piezo-electricity plate 310 made from a ceramic continues in the die-length direction, and is bisected by two, an actuator 31 and the generation-of-electrical-energy section 32. The actuator 31 polarizes in the thickness direction of a piezo-electric plate, and an electrode 311,312 (it hides and is not visible) spreads in each of vertical both sides throughout an actuator, and it is established in it. The generation-of-electrical-energy section 32 is polarized in the die-length direction of a piezo-electric plate, and the electrode 315 is formed in the end face vertical to a die-length shaft.

[0004]In order to perform pressure up with this piezoelectric transformer, alternating voltage ein is given from the exterior between the electrodes 311,312 of two upper and lower sides of an actuator (i.e., between input terminals 317,318). An actuator 31 vibrates in the die-length direction according to the piezo-electric transversal effect according to the above-mentioned alternating current input voltage ein. Electrical potential difference eout on which the oscillation of the die-length direction arose to the piezo-electric plate 310 by this, and pressure up of the same frequency as input voltage ein was carried out to the generation-of-electrical-energy section 32 by the piezo-electric longitudinal effect by that oscillation between the electrode 311 of an actuator, or 312 and the electrode 315 of a generation-of-electrical-energy section end face (in this case, between an electrode 312 and electrodes 315) (i.e., between output terminals 317,319) It is generated. If the frequency of the above-mentioned alternating current input voltage ein is made equal to the frequency of machine resonance of the die-length direction of the piezo-electric plate 310 here, very high output voltage will be obtained. The transformer shown in drawing 3 is a transformer which sets the die length in the primary mode, i.e., a piezo-electric plate, to L for the above-mentioned resonance, sets wavelength of the alternating current input voltage ein to lambda, and is driven by L=1- (lambda/2).

[0005]By the way, the piezoelectric transformer shown in drawing 3 is driven in the primary mode as mentioned above, and the ends side of the die-length direction hits the antinode of machine resonance. And the electrode 315 of the generation-of-electrical-energy section will be formed in the antinode of the resonance. Therefore, the node with the output terminal 319 to the end-face electrode 315 of the generation-of-electrical-energy section will be inevitably located in the antinode of machine resonance of the die-length direction of a piezo-electric plate. The connection structure on an electrode like soldering with the result, for example, lead wire, and an electrode 315 checks an oscillation of a piezo-electric plate, decline in transformer efficiency is caused or a failure like lowering of engine performance of a transformer, such as cutting in response to the oscillation with an excessive lead wire, or the dependability of connection is encountered. Then, in order to avoid the above-mentioned failure, the piezoelectric transformer driven by machine resonance in the 3rd die-length direction mode was proposed.

[0006]The perspective view of the piezoelectric transformer in the 3rd Rosen mold mode is shown in drawing 4. With reference to drawing 4, trisection of the piezo-electric plate 410 is carried out to order three, actuator 41L, the generation-of-electrical-energy section 42, and actuator 21R, covering the die-length direction. Actuator 41L is similarly polarized in the thickness direction of a piezo-electric plate in the transformer in the primary mode shown in drawing 3, and the electrode 411,412 (not shown) is formed in the vertical both sides. Actuator 41R is similarly polarized in the thickness direction, and equips vertical both sides with the electrode 413,414 (not shown). On the other hand, the generation-of-electrical-energy section 42 equips the location of the center of the die-length direction of the front face with the band-like electrode 415 prolonged crosswise, and polarizes mutually the part of the right-and-left both sides which sandwich the electrode 415 of the center in the reverse sense in the die-length direction.

[0007]In order to perform pressure up by this transformer, electrode 411,413 of

the top face of two actuators 41L and 41R are connected, and it connects with an input terminal 418. Moreover, electrode 412,414 at the bottom are connected and it connects with close and an output terminal 417. On the other hand, the band electrode 415 of the generation-of-electrical-energy section is connected to an output terminal 419. And alternating voltage ein is inputted from the exterior between input terminals 417,418, and the piezo-electric plate 410 is made to produce the oscillation of the die-length direction. In the generation-of-electrical-energy section 42, a pressure-up electrical potential difference arises according to the oscillation of the die-length direction of the above-mentioned piezo-electric plate between the electrode 411,413 of an actuator or an electrode 412,414, and the electrode 415 of the generation-of-electrical-energy section 42 (in this case, between an electrode 415 and electrodes 412,414) (i.e., between output terminals 417,419). Here, the frequency of the alternating current input voltage ein is chosen as the frequency (lambda/2) of machine resonance in the 3rd die-length direction mode of the above-mentioned piezo-electric plate, i.e., L=3-. If it does in this way and the node of the electrode 411,413 of an actuator and an input terminal 418 and the node of an electrode 412,414, and the close and an output terminal 417 will be chosen as the core of the die-length direction of each actuators 41L and 41R, those nodes can be located in the knot of resonance in the 3rd die-length direction mode of a piezo-electric plate, respectively. Moreover, the node of the band electrode 415 of the center of the generation-of-electrical-energy section and an output terminal 419 can also be located in the knot of resonance in the 3rd mode. Therefore, the problem of lowering of the transformer efficiency by the connection structure of the electrode 315 of a piezo-electric plate edge side and output terminal 319 in the transformer in the primary mode shown in drawing 3 or the dependability of connection improves.

[0008]However, the technical problem which should be improved that a pressure-up ratio is comparatively small remains also in the transformer of 3rd mode actuation with this veneer structure. Namely, the pressure-up ratio in this kind of piezoelectric transformer is decided by the inter-electrode thickness of the upper and lower sides of the actuators 41L and 41R of a laminated structure, and the die length of the generation-of-electrical-energy section 42, and a pressure-up ratio is so high that the thickness of a piezoelectric-ceramics layer is thin and the die length of the generation-of-electrical-energy section is long. However, since the piezoelectric transformer shown in drawing 4 is veneer structure, it is difficult for there to be a minimum in the practical thickness naturally, and to make it 0.5mm or less in the actual condition. Moreover, when thickness of a piezo-electric plate is made thin, the problem that the conversion efficiency of a piezoelectric transformer falls also arises.

[0009]The piezoelectric transformer of the laminated structure aiming at solution of the problem in the piezoelectric transformer in the above 3rd veneer structure modes is indicated by JP,6-224484,A. The perspective view of a transformer given [above-mentioned] in an official report is shown in drawing 5. With reference to drawing 5, the piezo electric crystal 510 is classified into three, actuator 51L, the generation-of-electrical-energy section 52, and actuator 51R, in order covering the die-length direction. It is the structure of Actuators 51L and 51R that the piezoelectric transformer shown in this drawing differs from the transformer shown in drawing 4. By this transformer, Actuators 51L and 51R are the laminated structures to which two or more laminatings of the piezo-electric ceramic layer 511 and the internal electrode 512 were carried out by turns. The external electrode 514,515 (not shown) is formed in each actuator top and bottom both sides. When a cross section vertical to the die-length direction of a piezo electric crystal is seen, the above-mentioned internal electrode 512 exposed the odd-numbered internal electrode to the side face on the right-hand side of a piezo electric crystal 510, and as it exposes to a left-hand side side face, and its gear tooth of two combs was clenched, it has exposed the even-numbered internal electrode to two side faces of a piezo electric crystal 510 alternately to place further. And the connection electrode 516,517 (it hides and is not

visible) in which the exposed part of the internal electrode was prepared in the both-sides side of a piezo electric crystal, respectively has connected also including the electrode 514,515 of a top and bottom front face.
[0010]If an electrical potential difference is applied to the surface electrode 514,515 of an actuator top and the bottom from the exterior with such structure, the electrical potential difference will be transmitted to each internal electrode 512. In that case, each internal electrode 512 is ** equivalent to the electrode which counters on both sides of the piezo-electric ceramic layer 511 in potential, and electric field join each ceramic layer 511. With about dozens of microns, since a piezo-electric ceramic layer is dramatically thin, it can add very high electric field to each ceramic layer 511 also with the same input voltage after all compared with the case of veneer structure, and it can make a pressure-up ratio high. And since the thickness as [whole] a piezo electric crystal can also secure Actuators 51L and 51R by making it a laminated structure, there is also no decline in conversion efficiency like [when only making thickness of a piezo-electric plate thin with the piezoelectric transformer of veneer structure].
[0011]The connection electrode 516,517 connected for one characteristic of the piezoelectric transformer of the laminating mold shown in drawing 5 here to place an internal electrode and a surface electrode further in each actuator is the side face of each actuators 51L and 51R, and is formed in the center section of the die-length direction of the actuator.
[0012]
[Problem(s) to be Solved by the Invention]According to the piezoelectric transformer of the laminating mold mentioned above, inhibition of the oscillation by the connection structure of the electrode for pressure-up electrical-potential-difference drawing (electrode 315 in drawing 3) and output terminal which were produced by the transformer of primary mode actuation, and decline in conversion efficiency are improvable by considering as the structure driven in the 3rd mode. Moreover, a pressure-up ratio and conversion efficiency can be raised rather than the transformer of veneer structure by making an actuator into a laminated structure.
[0013]However, also in the laminating mold piezoelectric transformer of this 3rd mode actuation, there is a problem that a transformer cannot yet take out the conversion efficiency which should be shown essentially fully. Namely, while this transformer is operating, as a broken line shows all over the top view of the actuator which shows drawing 6 (a), and the side elevation of the actuator which shows drawing 6 (b), it not only vibrates in the die-length direction, but it is displacing the piezo electric crystal 510 in the cross direction and the thickness direction. Here, as shown in drawing 5, forming the electrode 516,517 for internal electrode connection in the core of the die-length direction of each actuator will form the electrode in the location like the maximum serious grade of the cross direction of a piezo electric crystal and the thickness direction maximum being serious. Consequently, the electrode 516,517 for these connection will check the variation rate of the cross direction of a piezo electric crystal 510, and the thickness direction, and the conversion efficiency of a transformer will fall.
[0014]Therefore, this invention aims at raising the conversion efficiency further from before in the piezoelectric transformer of the 3rd mode actuation which made the actuator the laminated structure.
[0015]
[Means for Solving the Problem]With the actuator where, as for the laminating mold piezoelectric transformer of this invention, a long tabular piezo electric crystal includes one edge in order covering the die-length directionIt is classified into three fields of the generation-of-electrical-energy section including the center section of the die-length direction, and the actuator containing the other-end section. The band-like electrode prolonged crosswise [of a piezo electric crystal] into a part including the center of the die-length direction of the front face is prepared in said generation-of-electrical-energy

section. The laminating of the wrap electrode layer is mostly carried out by turns in the whole region, and the electrode layer of the outermost layer of drum of a laminating is the laminated structure of a wrap gestalt. said two actuators -- respectively -- a piezoelectric-ceramics layer and its piezoelectric-ceramics layer --In a different field from the principal plane of said piezo electric crystal, the electrode for connection of an electric insulation-lot prepares said electrode layer for each who connects by turns for placing further, and it is set to the laminating mold piezoelectric transformer of ******** structure. It is characterized by preparing four electrodes for connection of said two actuators in four corners of the piezo electric crystal when seeing a piezo electric crystal from a direction vertical to the principal plane.
[0016]The cross direction, the thickness direction, and the die-length direction of four corners when seeing a piezo electric crystal from a direction vertical to the principal plane are not the maximum locations of a variation rate. Therefore, the electrode for connection prepared there has checking [little] the oscillation at the time of transformer actuation compared with the former.

[0017]
[Embodiment of the Invention]Next, the gestalt of operation of this invention is explained with reference to a drawing.
[0018](Example 1) Drawing 1 is the perspective view of the laminating mold piezoelectric transformer by the example 1 of this invention. That the transformer by this this example differs from the conventional transformer with reference to drawing 1 and drawing 5 is a point prepared in both the sides of an end face vertical to the die-length direction, when the electrode 116,117 for connecting the internal electrode 112 in actuator 11L and 11R looks at a piezo electric crystal 110 from a direction parallel to the die-length direction. About the laminated structure of an actuator, the structure of the generation-of-electrical-energy section, and the actuation approach in the 3rd mode, since it is the same also in the conventional laminating mold piezoelectric transformer, explanation is omitted.
[0019]this invention person etc. produced the piezoelectric transformer of this example using the green sheet method. In the ingredient of the piezoelectric-ceramics layer 111, it is NEPEC8 (trade name.). Tokin Make was used. With the screen printing which used the baking type Ag-Pd alloy paste, after forming the pattern of the above-mentioned conductive paste on the green sheet of a piezo-electric ceramic, an internal electrode 112 is carrying out two or more sheet laminating of the pattern formation finishing green sheet of the conductive paste, and calcinating it, and was really calcinated with the piezo-electric ceramic layer 111. Baking conditions are temperature:1100 degree C, and keeping time amount:2 hours. the pattern of an Ag-Pd alloy paste -- the case of the oddth layer -- one corner section -- the case of the eventh layer -- another corner section -- as -- it is the pattern with which a paste is not printed by only the corner section by turns for every layer. There is [five layers and four internal electrode layers of the laminated structure of Actuators 11L and 11R] a ceramic layer. The thickness of each ceramic layer is 200 micrometers, and the whole thickness is 1mm.
[0020]Die length of 42mm, width of face of 5mm, and a dimension with a thickness of 1mm are processed after the above-mentioned baking. A baking type Ag-Pd alloy paste ActuatorL [11] and 11R top and bottom both sides, By screen-stenciling into both the sides of two end faces vertical to the die-length direction, and the part which should form the output electrode 118 of the generation-of-electrical-energy section 12, and calcinating on the conditions for temperature:700 degree C, and keeping time amount:15 minutesThe surface electrode 114,115 (it hides and is not visible), the electrode 117,116 for connection, and output electrode 118 of ActuatorL [11] and 11R top and the bottom were formed.

[0021]Subsequently, the generation-of-electrical-energy section 12 was polarized by cutting the electrical potential difference which is impressing electric field

into air with a temperature of 300-350 degrees C in the state of 0.5-0.7kV [mm] /, in addition electric-field impression after lowering temperature to 100 degrees C using a polarization fixture. Then, Actuators 11L and 11R were polarized by impressing 2-3kV /of electric fields mm in silicone oil with a temperature of 100-200 degrees C.

[0022]Thus, when the electrical potential difference was impressed by having used resistance of 100kohm as the load and the transformer property was evaluated about the piezoelectric transformer of obtained this example, the effectiveness which was 93% conventionally has been improved to 98%. Moreover, what [a pressure-up ratio's] was 44 times conventionally improved by 48 times.

[0023]As this shows with a broken line all over the side elevation of the piezo electric crystal shown in the top view and drawing 6 (b) of the piezo electric crystal shown in drawing 2, in four corners of a principal plane, the cross direction, the thickness direction, and the die-length direction are not [variation rates] maxes. Therefore, even if it prepares the electrode for connection in these each part, the electrode for connection is because the inhibition factor of an oscillation does not become at all.

[0024](Example 2) The cure type electrode material was used for the electrode formation on the front face of a piezo electric crystal, polarization conditions were changed according to this, and the piezoelectric transformer of an example 2 was produced. In this example, the cure of the cure type Ag paste was carried out on the conditions for temperature:200 degree C, and keeping time amount:15 minutes after printing to a position like the example 1 as an electrode material on the front face of a piezo electric crystal.

[0025]Next, using the polarization fixture, in silicone oil with a temperature of 100-200 degrees C, 1.5-2.0kV /of electric fields was impressed mm, and the generation-of-electrical-energy section 12 was polarized.

[0026]Then, 2-3kV /of electric fields was impressed mm into silicone oil with a temperature of 100-200 degrees C, and Actuators 11L and 11R were polarized.

[0027]Thus, when the electrical potential difference was impressed by having used resistance of 100kohm as the load and the transformer property was evaluated about the piezoelectric transformer of obtained this example, the effectiveness which was 93% conventionally has been improved to 98%. Moreover, what [a pressure-up ratio's] was 44 times conventionally improved by 48 times. Although this example has stopped at a little low result in respect of improvement in a property compared with the example 1, it has the advantage that cost can be reduced in respect of the ingredient used for the process and surface electrode of manufacture. In this example, the price of the manufacturing cost having been 80 yen per piece in the example 1 was 60 yen per piece.

[0028]In addition, although each example to this shows the example which prepared the electrode for connection of an actuator in both the sides of an end face vertical to the die-length direction of a piezo electric crystal 110, formation of the electrode for connection is not restricted to this. You may prepare in the edge of a side face parallel to the die-length direction of a piezo electric crystal. Moreover, even if it forms so that an end face may be covered from a piezo electric crystal side face with each corner exceeding ** vertical to a principal plane, of course, it is good.

[0029]In addition, although the case of veneer structure was explained about the generation-of-electrical-energy section, of course, the thing of the structure which carried out the laminating of the same internal electrode as an actuator and the piezo-electric ceramic layer by turns can also be manufactured according to the same process again.

[0030]Furthermore, other combination is sufficient as long as it is not only this but the ingredient and this which have piezoelectric, and the electrode material which can really be calcinated as an ingredient of a piezo-electric ceramic layer and an internal electrode, although the piezo-electric ceramic and Ag-Pd alloy paste of a PZT system were used.

[0031]
[Effect of the Invention]As explained above, while connecting the internal electrodes in an actuator, by this invention, it has prepared in four corners when seeing the electrode for connection for connecting with a surface electrode from a direction vertical to the principal plane of a piezoelectric transformer in the piezoelectric transformer of the laminating mold which made the actuator the laminated structure.
[0032]Thereby, according to this invention, conversion efficiency and a pressure-up ratio can be raised compared with the conventional laminating mold piezoelectric transformer.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]It is the perspective view of the laminating mold piezoelectric transformer by the examples 1 and 2 of this invention.
[Drawing 2]It is the plan showing the working displacement condition of the laminating mold piezoelectric transformer shown in drawing 1.
[Drawing 3]It is the perspective view of the laminating mold piezoelectric transformer of the conventional primary veneer structure mode actuation.

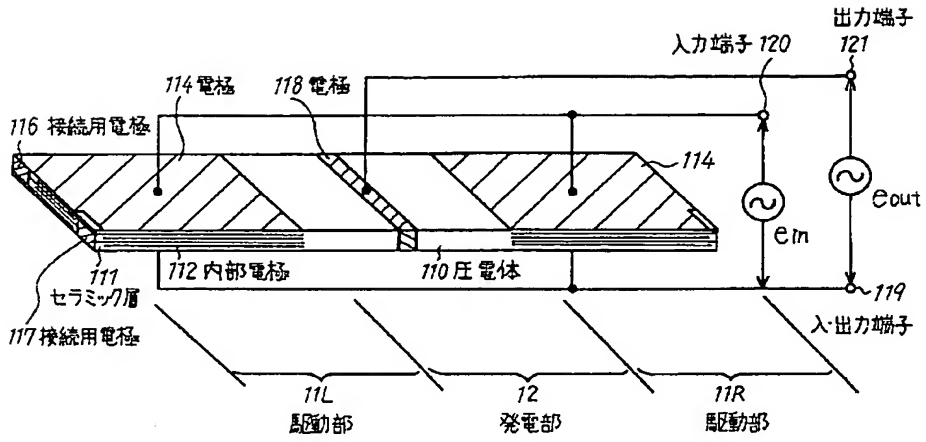
[Drawing 4]It is the perspective view of the laminating mold piezoelectric transformer of the conventional 3rd veneer structure mode actuation.
[Drawing 5]It is the perspective view of the laminating mold piezoelectric transformer of the conventional 3rd laminated-structure mode actuation.

[Drawing 6]It is the plan and side elevation showing the working displacement condition of the laminating mold piezoelectric transformer shown in drawing 5.

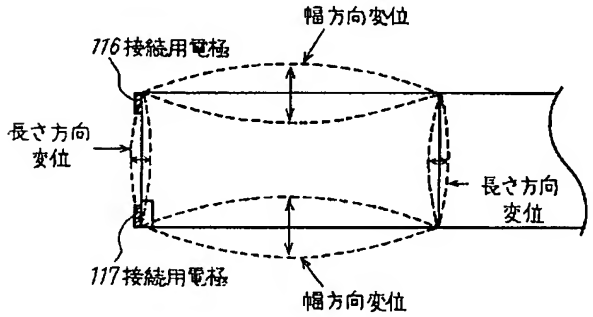
[Description of Notations]
11L, 11R Actuator
12 Generation-of-Electrical-Energy Section
110 Piezo Electric Crystal
111 Piezo-electric Ceramic Layer
112 Internal Electrode
114 Actuator Surface Electrode
116,117 Electrode for connection
118 Generation-of-Electrical-Energy Section Surface Electrode
119 Input Terminal
120 Close and Output Terminal
121 Output Terminal

DRAWINGS

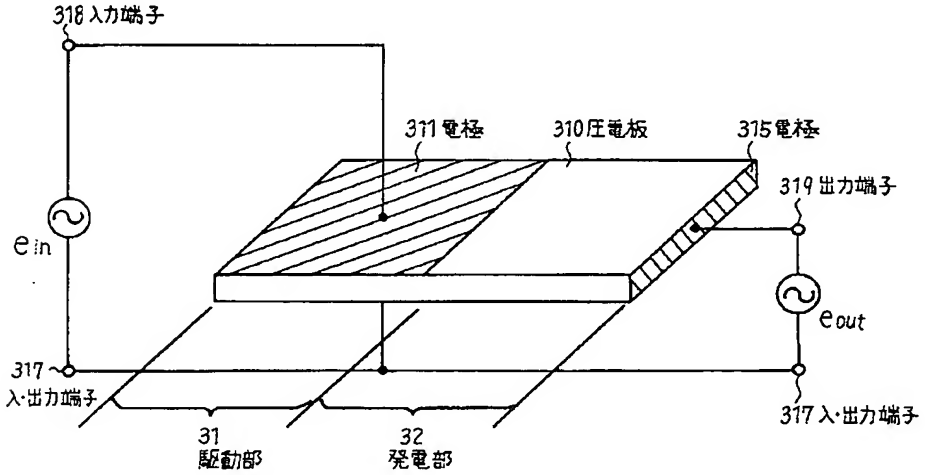
[Drawing 1]



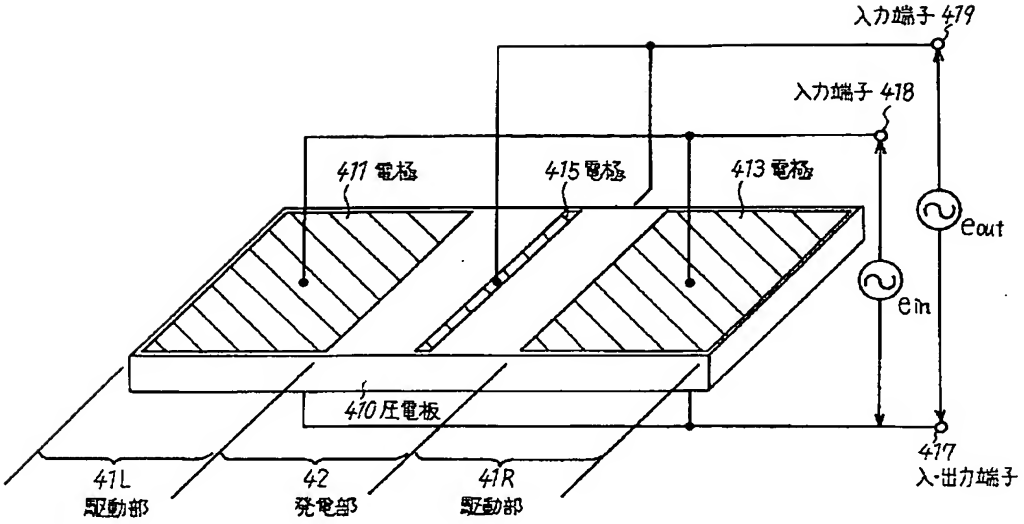
[Drawing 2]



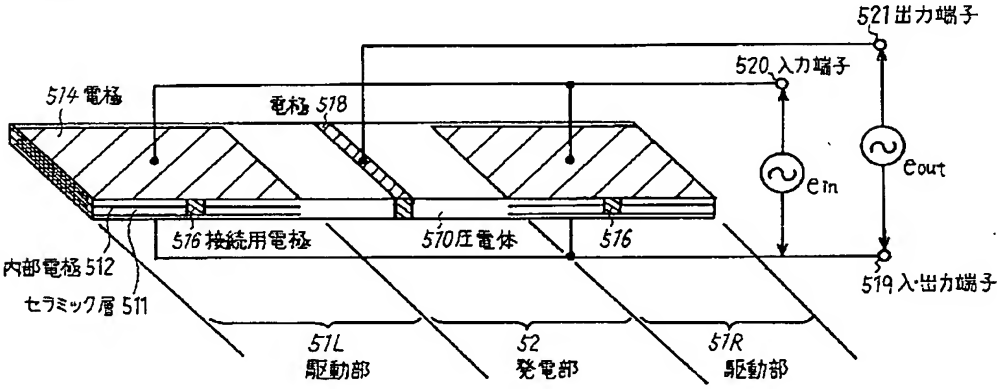
[Drawing 3]



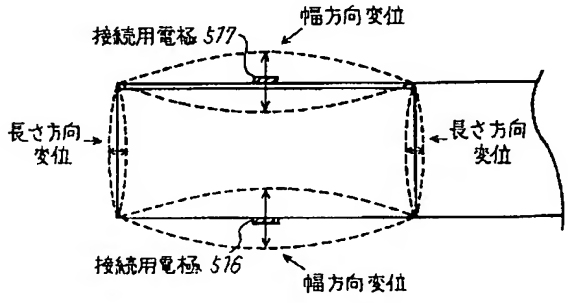
[Drawing 4]



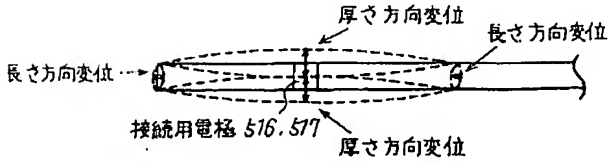
[Drawing 5]



[Drawing 6]



(a)



(b)